RELIABILITY BASED FATIGUE LIFE CONSTRAINTS FOR STRUCTURAL OPTIMIZATION: GENERAL APPROACH

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It is desirable to obtain fatigue life criteria in native finite element analysis result types such as stresses and strains for reducing redesign efforts. In most structural design problems, the design goal is defined in terms of life ultimately. However, the fatigue life of structures can be evaluated just after the first pass of design iteration in conventional design process. Even though optimization technique reduces design iteration successfully, the design results would be over-designed or under-designed depending on how to determine the objective and constraints, which still requires designer's intuition and experience along with some factor of safety and design iteration to meet the design life.

In this paper, fatigue life constraints are obtained in the form of stresses with the development of a probabilistic durability limit state model, which is calculated from a fatigue damage model. The methodology decouples the calculation of fatigue life constraints and optimization with reliability analysis to improve computational efficiency. Subsequently the calculated stress scale factor can be used as stress constraints for the optimization directly. The fatigue damage model has been developed based on the assumption on the uniform change of stress range histograms due to shape change of structures during optimization. Both stress life and strain life methods can be used for fatigue damage calculation.

The methodology provides reliability based fatigue life constraints that consider structural fatigue life in design optimization directly according to the expected uncertainties in service loads, weld/connection types, material characteristics and finite element modeling. The proposed methodology has been validated with examples and compared with the conventional design method. The results show the methodology generates the optimal design of fabricated structures that meets reliability target with given probabilistic variation of service loads, material properties and finite element model.